

IAP9 Rec'd PCT/PTO 29 AUG 2006
DESCRIPTION

Linear drive device provided with an armature body having a magnet carrier

5 [001] The invention relates to a linear drive device comprising at least one excitation winding for producing a variable magnetic field and provided with at least one associated magnetic-flux-carrying yoke body as well as an armature body which comprises a magnet carrier provided with at least two permanent magnet parts and to which an axial oscillation movement can be transferred by the magnetic field of the excitation winding. A corresponding 10 drive device is deduced from US 5 559 378 A.

[002] Corresponding linear drives are used in particular to set pump plungers of compressors in linear oscillating vibration. The system comprising such a compressor and a linear drive device is therefore also designated as a linear compressor (see, for example, JP 2002-031054 15 A). In corresponding known linear compressors, the armature body capable of oscillating, forms a spring-mass system designed for a certain oscillation frequency.

[003] The known drive device comprises at least one excitation winding in a laminated iron yoke core in an E-shape. Its magnetic field exerts a force which depends on the direction of 20 the current on two alternately polarised plate-shaped permanent magnets or on a linearly movable magnet carrier of an armature body, which can be used to drive, for example, a pump plunger of a compressor.

[004] The air gap between the pole surfaces of such a yoke body and the surface of the 25 permanent magnets represents an additional resistance in the magnet circuit which reduces the magnetic field strength produced by the excitation winding in the air gap and thus correspondingly reduces the driving force.

[005] During the oscillating movement of the armature body, lateral parts of its magnet carrier 30 dip into the air gap field at the pole surfaces of the yoke carrier, inducing eddy currents, losses and a corresponding braking force in electrically conductive materials. A corresponding effect can be observed in known drive units whose magnet carrier is generally made of highly

conducting aluminium, and the permanent magnets provided with thin glass-fibre reinforced plastic covers can be stuck in recesses of the support.

[006] It is thus the object of the present invention to construct the linear drive device provided
5 with the features specified initially such that the aforementioned induced braking force is reduced.

[007] This object is achieved according to the invention with the features specified in claim 1.
Accordingly, in the drive device, the magnet carrier should be constructed, at least in parts, of
10 an electrically insulating material which dips into the magnetic field area defined by the pole surfaces of the yoke body and the excitation winding or comes to rest therein.

[008] The advantages associated with this configuration of the drive device can be seen in particular in that as a result of using insulating material for the magnet carrier, no eddy
15 currents are induced therein under the pole surfaces. Thus, no additional braking force is induced by this region of the magnet carrier.

[009] Advantageous embodiments of the linear drive device according to the invention are obtained from the dependent claims. In this case, the embodiment according to claim 1 can be
20 combined with the features of one of the dependent claims or preferably also with those of several dependent claims. Accordingly, the following features can be additionally provided for the drive device:

- The magnet carrier can consist entirely of an insulating material. Instead, it is also possible that this consists of metal and the parts of the magnet carrier which dip into the magnetic field area of the yoke body and/or the excitation winding are constructed of an insulating material. Consequently, no eddy currents are induced in these insulating material parts under the pole surfaces.
- It is particularly advantageous if each magnet part with respect to the associated yoke body and/or the excitation winding are covered by a magnet cover made of a ferromagnetic sheet or a corresponding layer, the magnet covers being spaced axially apart by means of a spacing joint. These ferromagnetic covers are used firstly for secure fixing of the magnet parts in or on the magnetic carrier. Secondly, they reduce

the effective magnetic air gap, increase the field of the excitation winding(s) and thus the driving force.

- In this case, the ferromagnetic magnet covers can advantageously be spaced apart from one another by a distance $a > 2 s$, where s is the distance from the surface to the pole surfaces of the yoke body. A magnetic short circuit can thus be avoided between the neighbouring magnet parts.
5
- Each of the ferromagnetic magnet covers advantageously covers a larger area than the respectively associated magnet part.
- An Fe-Si alloy is preferably used as the material for the ferromagnetic magnet covers.
10
- The thickness of the ferromagnetic covers is advantageously selected between 0.2 mm and 1.5 mm, preferably between 0.35 and 1 mm.
- The magnet parts are appropriately embodied as plate- or sheet-shaped.
- The armature body constructed according to the invention is preferably rigidly connected to a pump plunger of a compressor.
15

[010] Further advantageous embodiments of the linear drive device according to the invention are deduced from the dependent claims not discussed previously and the drawings.

[011] The invention is explained in detail hereinafter using preferred exemplary embodiments
20 with reference to the drawings. In the figures:

[012] Figure 1 is a schematic oblique view of a linear drive device according to the invention,

[013] Figure 2 is an oblique view of an armature body of the drive device,
25

[014] Figure 3 shows, in part figures 3a and 3b, a longitudinal section or cross-section through the armature body according to Figure 2,

and

30 [015] Figure 4 shows, in part figures 4a and 4b two different positions of the armature body according to Figures 2 and 3 with respect to two opposite yoke bodies.

[016] In the figures corresponding parts are each provided with the same reference numerals.

[017] In the linear drive device according to the invention shown in Figure 1, embodiments known per se such as those provided for linear compressors are assumed. Essentially only an upper and a lower part 2a or 2b of such a drive device 2 can be seen from the oblique view in the figure, these parts being embodied symmetrically with respect to a plane of symmetry SE. The drive device 2 comprises two symmetrically opposed excitation coils 4a and 4b, each having at least one magnetic-flux-carrying yoke body 5a or 5b. The yoke bodies, for example, have the known E-shape. Located in a central channel-like or slit-like opening 7 between these yoke bodies or their pole surfaces F_p is a magnetic armature or armature body 8 comprising two permanent magnets 9a and 9b, for example. Their anti-parallel-directed magnetisations M perpendicular to the plane of symmetry are indicated by the arrowed lines. The armature body 8, designated as "armature carriage" and described in detail in the following figures can execute an oscillating movement in the axial direction in the variable magnetic field of the excitation coils 4a and 4b. This armature body has axially lateral extension parts 10 not described in detail which are advantageously rigidly connected to a pump plunger 11 of a compressor V not shown in detail in the figure. This pump plunger consequently executes the axially oscillating movement of the armature part 8 about an armature stroke H.

[018] Figures 2, 3a and 3b show detailed views of an armature body 8 or carriage constructed according to the invention. This comprises a magnet carrier 12 which should consist of an electrically insulating material, at least in parts, which dips into the magnetic field area defined by the pole surfaces of the yoke body and excitation windings or comes to rest therein. The field lines directed perpendicularly to the armature body define the limits of the region. Said parts advantageously extend from the insulating material beyond the limits of this region. The magnet carrier 12 comprises a frame portion 13, e.g. made of aluminium in which web-like or plate-shaped insulating material inserts 14a and 14b are fixed in axially opposed front regions. Naturally, the frame portion 13 can also be made completely of an insulating material, where the insulating material inserts can then be integrated parts of the frame portion. Two plate-shaped permanent magnet parts 9a and 9b arranged one after the other in the axial direction are clamped between the two insulating material inserts 14a and 14b

[019] or fixed in some other fashion.

[020] As can be further deduced from Figures 2, 3a and 3b, each of the plate-shaped magnet parts 9a and 9b can be covered with a magnet cover made of a ferromagnetic material on each surface facing a yoke body with excitation winding. Since according to the selected

5 exemplary embodiment, two yoke bodies 5a and 5b which are symmetrical with respect to the plane of symmetry SE should be provided between which the armature body 8 can move in an oscillating manner (see Figure 1), ferromagnetic covers 16a or 16b and 17a or 17b are applied to both flat sides of each magnet part 9a and 9b. These reduce the respective effective magnetic air gap, increasing the field generated by the excitation windings. Thus, a higher
10 axial driving force on the armature body 8 or its magnet parts is obtained.

[021] The ferromagnetic covers 16a, 16b, 17a and 17b can in particular be embodied in the form of a metal sheet or a corresponding layer. Preferably provided for this purpose are ferromagnetic sheets of relatively low electrical conductivity (below that of the known

15 aluminium), in particular so-called electric sheet made of an Fe-Si alloy, the thickness d of this sheet metal generally being between 0.2 mm and 1.5 mm, preferably between 0.35 mm and 1 mm. It is also advantageous if these sheets project somewhat over the associated magnet parts on three sides, they at least partly cover the edge of the recesses in the frame portion 13 in which the magnet parts 9a and 9b are to be fitted and are fixed to the magnet parts in the
20 carrier frame, for example, are glued therein. The associated ferromagnetic sheets 16a and 16b or 17a and 17b are mutually spaced in the area of the centre at a joint 18 between the two oppositely magnetised permanent-magnet parts 9a and 9b to thus prevent a magnetic short circuit. The axial extension a of a corresponding spacing joint 19 should preferably be selected so that this is twice the spacing s from the surface to the pole surface F_p of the
25 corresponding yoke body 5a or 5b.

[022] Figures 4a and 4b each show the maximum deflection of the armature body 8 with its magnet carrier 12 as shown in Figures 2, 3a and 3b during an oscillating movement under the pole surfaces F_p of the yoke bodies 5a and 5b.

- [023] Reference list
- [024] 2 Drive device
- [025] 2a Upper part
- [026] 2b Lower part
- [027] 4a, 4b Excitation windings
- [028] 5a, 5b Yoke body
- [029] 7 Gap
- [030] 8 Armature body
- [031] 9a, 9b Magnet parts
- [032] 10 Extension part
- [033] 11 Pump plunger
- [034] 12 Magnet carrier
- [035] 13 Frame portion
- [036] 14a, 14b Insulating material inserts
- [037] 16a, 16b Ferromagnetic covers
- [038] 17a, 17b Ferromagnetic covers
- [039] 18 Joint
- [040] 19 Spacing joint
- [041] M Magnetisations
- [042] F_p Pole surfaces
- [043] SE Plane of symmetry
- [044] V Compressor
- [045] H Armature stroke
- [046] a Extension
- [047] s Distance